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FEBRUARY 1963

OOAMA

AIRMUNITIONS TEST REPORT

SHELF LIFE TEST ON ROCKET MOTORS, 15-KS-1000, MK 6 MODS

OGDEN AMA

SHELF LIFE TEST

ON

ROCKET MOTORS, 15-KS-1000, MK 6 MODS

by

Robert M. Cavett

PUBLICATION REVIEW

This report has been reviewed and is approved

Alex D. Peresich

ALEX D. PERESICH
Chief,
Engineering and Test Division
2705th Airmunitions Wing

FEBRUARY 1963

2705TH AIRMUNITIONS WING
OGDEN AIR MATERIEL AREA
AIR FORCE LOGISTICS COMMAND
UNITED STATES AIR FORCE
Hill Air Force Base, Utah

NOTICES

The information furnished herewith is made available for study with the understanding that the Government's proprietary interests in and relation thereto shall not be impaired. It is desired that the Judge Advocate's Office, WCJ, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, be promptly notified of any apparent conflict between the Government's proprietary interests and those of others.

The conclusions and recommendations made in this report are not to be considered directive in nature. This type information becomes official only when published in Technical Orders or other applicable Air Force publications.

ADMINISTRATIVE DATA

PURPOSE OF TEST:

This test was to verify the existing nine year shelf life and determine if any extension is possible.

MANUFACTURER:

Aerojet General Corporation, Azusa, California

MANUFACTURER'S TYPE OR MODEL DESIGNATION:

MOTOR: Rocket Motor, 15-KS-1000, Mk 6 Mods (FSN 1340-309-5092-H340)

IGNITER: Igniter for 15-KS-1000 Rocket Motor, Mk 165 (FSN 1340-309-5095-H403)

DRAWINGS AND SPECIFICATIONS:

Specification ATS-S2.109 Aerojet-General Corporation
Igniter Drawing 39415 Aerojet-General Corp
Igniter Specification ATP-SA-10I.005k Aerojet-General
Motor Drawing 39060 Aerojet-General Corp

QUANTITY OF ITEMS TESTED:

24 each motors and igniters

SECURITY CLASSIFICATION:

Unclassified

TESTS CONDUCTED BY:

OOAMA (OOYET - 2705th Airmunitions Wing)

Test Director: Hoyt O. Brown, Major, USAF

Project Engineer: Robert M. Cavett, Chemical Engineer

DISPOSITION OF SPECIMENS:

All metal parts generated from this operation were inspected, certified inert and turned over to the Redistribution and Marketing Division in accordance with Technical Order 11C3-1-3 and HAFBR 136-2.

ABSTRACT

This investigation was one phase of a series established to determine the ultimate life of the 15-KS-1000 Rocket Motor. To accomplish this, 24 motors were visually and radiographically inspected and fired using static facilities at Hill Air Force Base, Utah.In order to best evaluate serviceability, temperature conditioning was accomplished at both high and low extremes of 150°F and -75°F.

The motors, as in the past, continued to function without incident. Some small drift of the data from normality toward the specifications limits was noted but was not significantly detrimental to effect serviceability. The previous established life of 9 years was confirmed and an extension to 10 years is recommended.

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INTRODUCTION

A total of 120 15-KS-1000 Rocket Motors were initially reserved for shelf life testing purposes. These units were stored at Eielson Air Force Base, Alaska until 1959, at which time they were shipped to Hill AF Base, Utah. Prior to this test, the established shelf life of 5 years had been extended, by previous test, to nine years. This test is the latest phase in determining the maximum life of this motor.

The tests were accomplished in accordance with 00YEE Test Directive C-1-509-Y-2, 11 April 1961 and 00YEG SOP C-1-509-Y-2, 18 April 1962. Any inquiries on this report should be addressed to the Ground Launch Missiles Branch (00YEG), Engineering and Test Division (00YE), 2705th Airmunitions Wing (00Y). This document is the final report for Project C-1-509-Y-2.

DESCRIPTION

The 15-KS-1000 Rocket Motor consists of a chamber assembly and an Aft-cap assembly which contains an outside restrieted, internal burning, slotted propellant grain. The various components and dimensions of the motor are shown in Figures 1 and 2.

Principle data on motor manufacture are as follows:

Rocket Motor:

Overall Length (Avg)	33.45 Inches
Diameter (Principal)	10.30 Inches
Diameter (Maximum)	11.45 Inches
Weight (Avg):	
Loaded	144 Pounds
Expended	72 Pounds

Design Safety Data of the 15-KS-1000 Rocket Motor:

Temperature range	-65°F to 140°F
Ultimate strength of chamber	2400 psi
Operating pressure range	447 to 735 psi
Pressure-release diaphragm range	1200 to 1600 psi
Allowable acceleration along axis	18 g
Allowable acceleration normal to axis	12 g

Propellant Grain Manufacture:

Type	Aeroplex AN-583AF
Manufacture method	Cast
Grain Design	Slotted, Internal Burning

Propellant Grain Dimensions:

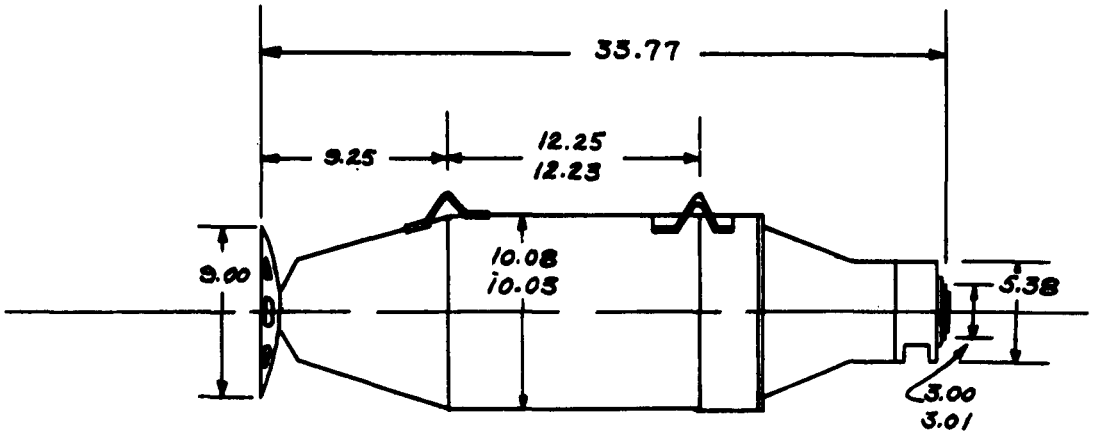
Length	26.5 Inches
Diameter	9.7 Inches
Web Thickness	3.4 Inches

Propellant Composition (% by weight) is classified Confidential, therefore it has been omitted from this report. It can be found in 00YEE Confidential Report 00Y-TR-61-11, February 1961 or in the Solid Propellant Information Agency Manual, M-1

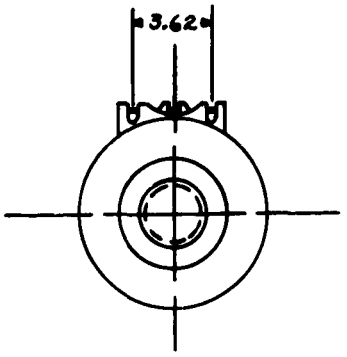
The igniter used with the 15-KS-1000 Rocket Motor is the Mk 165 which is also manufactured by the Aerojet-General Corporation. The electrical characteristics of the Mk 165 Igniter are:

Resistance	0.25 ($\pm$ 0.06) ohm
Recommended Firing Current	25 amp
Maximum No-Fire Current	0.04 amp

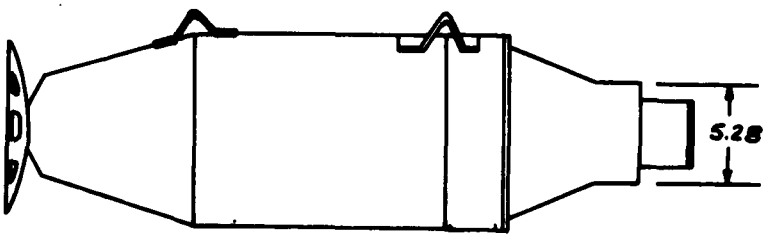
The Mk 165 Igniter uses a glow plug to ignite a charge of black powder which in turn ignites the main charge of alclo pellets. The internal configuration of the Mk 165 Igniter is shown in Figure 3.



Mark 6 Mod 0



Aft-End View



Mark 6 Mod 1

All Dimensions are in Inches

FIGURE 1. External Dimensions of the Rocket Motor, 15-KS-1000

LEGEND for FIGURE 2

1. Nozzle
2. Pressure Release Diaphragm
3. Safety Diaphragm Deflector Cone
4. Retainer Ring
5. Aft-Cap Assembly
6. Propellant Grain
7. Mounting Lugs
8. Insulating Boot
9. Chamber Assembly
10. Handling Stand

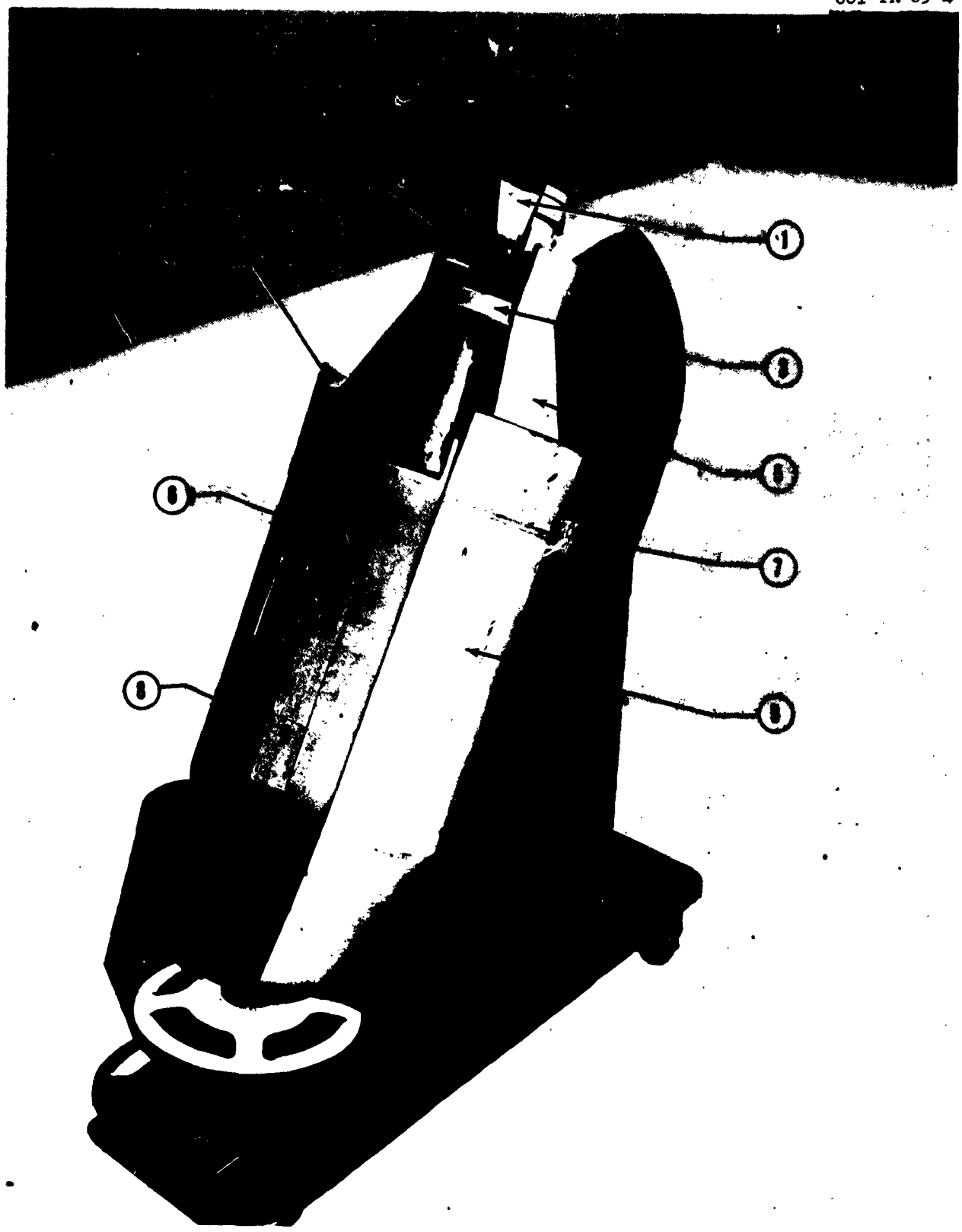


FIGURE 2. Cutaway View of a 15-KS-1000 Rocket Motor Showing its Major Components.

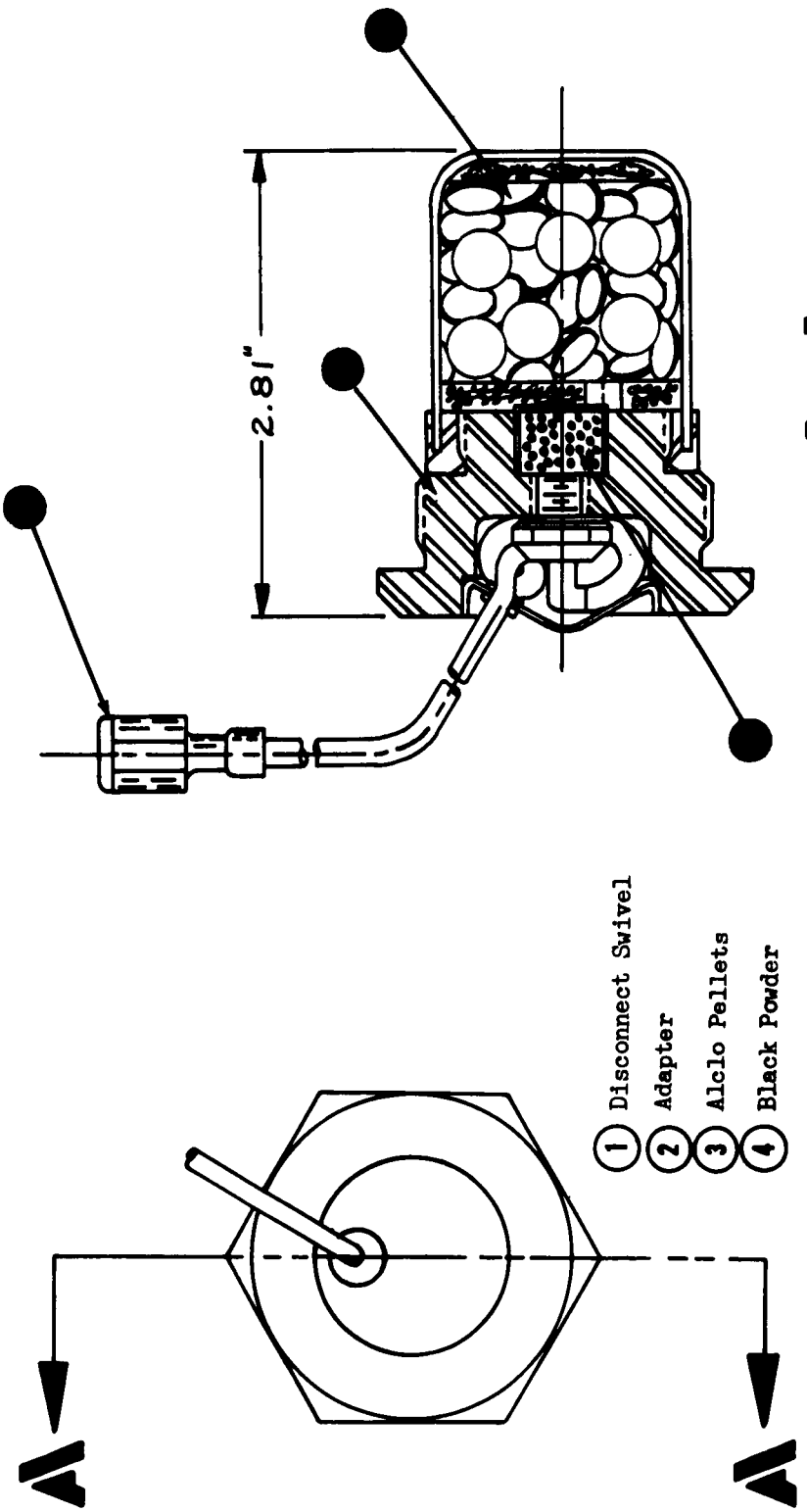


FIGURE 3. The Mark 165 Igniter Showing Its Internal Configuration.

TEST PROCEDURES

Twenty-four 15-KS-1000 Rocket Motors were visually and radiographically inspected. Five motors were disassembled and a thorough internal inspection performed. Ten motors were temperature conditioned to -75°F, four to 70°F and ten to 150°F. All were fired and the results evaluated. The equipment used for the static firings are shown in Figure 4.

TEST RESULTS

VISUAL INSPECTION

The visual inspection, both internal and external, was accomplished with no defects found. The five motors which were disassembled were in excellent condition. These motors were reassembled and fired with the others.

RADIOGRAPHIC INSPECTION

Each motor was X-rayed in two positions with a 2MEV unit. The defects (voids) found are listed in Table 1. These voids are normal in size and quantity for this motor and have never been known to produce adverse results during static tests.

IGNITER CHECK

All igniters were examined and tested for continuity prior to conditioning. Seven of the 24 igniters had high resistances by from 0.03 to 0.26 ohm. These slightly high values had no effect on motor performance. All others were within allowable limits.

MOTOR NO.	QTY	FOREWARD END INCHES	QTY	CENTER SECTION INCHES	QTY	AFT END INCHES
1			1	.125 X .125	1	.125 X .125
2			1 2	.5 X .5 .125 X .125		
3			3	.25 X .25		
5		30 Scattered Voids		.25 X .25		.125 X .125
6	5	.25 X .25		.125 X .125		
7			1	.25 X .25	1	.125 X .125
8			1	.25 X .25	3	.125 X .125
9			1 5	.5 X .5 .25 X .25	3	.125 X .125
10	1	.75 X .75	1	.125 X .125	2	.125 X .125
11					2	.125 X .125
12					2	.25 X .25
13			3	.25 X .25	2	.125 X .125
15			1	.25 X .25	2	.25 X .25
17			1 2	.5 X .5 .125 X .125		
18	1	.125 X .125	2	.25 X .25	1	.125 X .125
19			1 1	.25 X .25 .125 X .125		
20					1	.125 X .125
21	1	.25 X .25	1	.125 X .125	1	.125 X .125
22			1	.125 X .125	1 1	.5 X .5 .125 X .125
23					1	.5 X .5
24	1	.5 X .5	1	.5 X .5	2	.125 X .125

All defects are internal voids.

TABLE 1. Results of Radiographic Inspection.

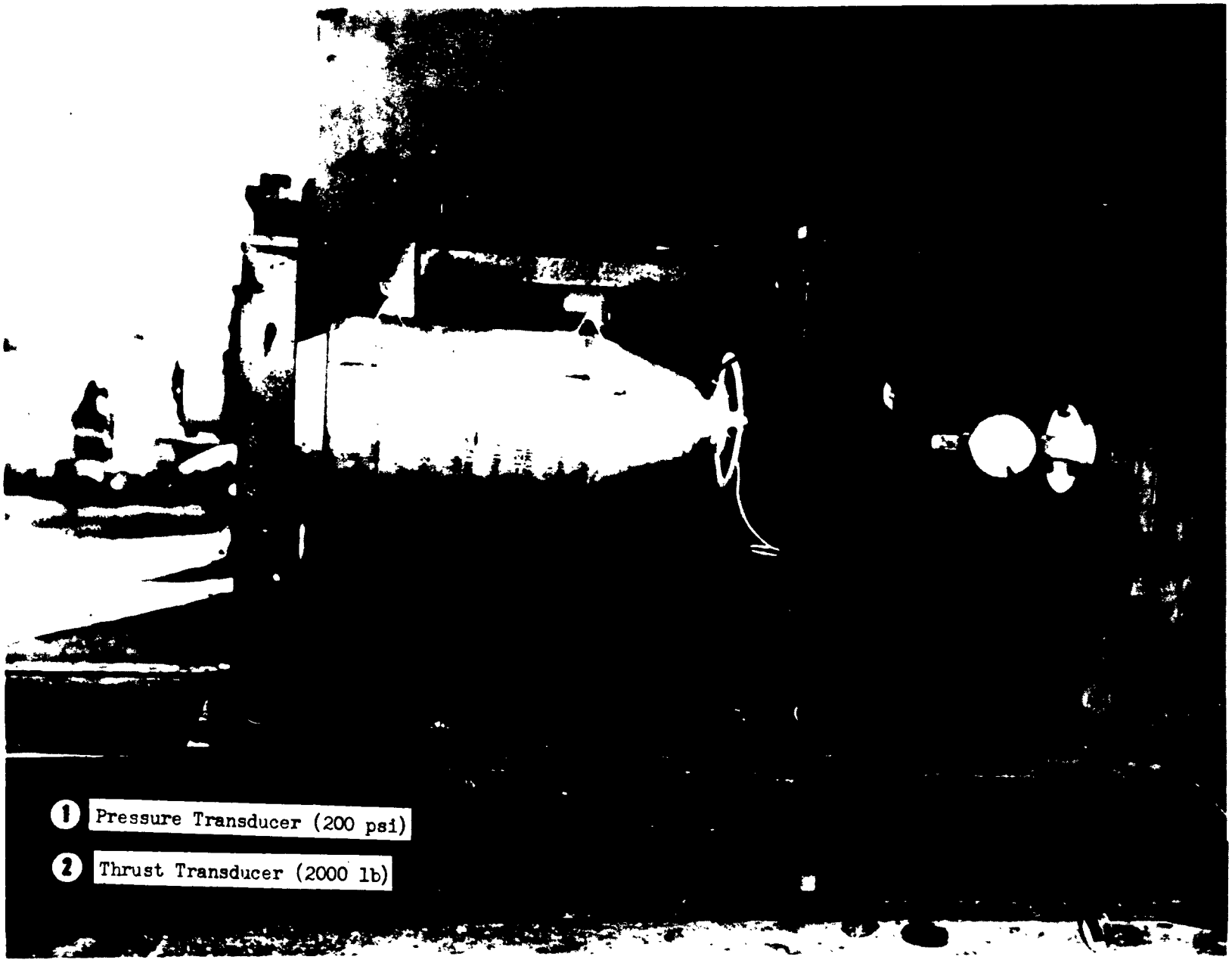


FIGURE 4. Static Test Arrangement for the 15-KS-1000 Rocket Motor.

A graphical representation of the 15-KS-1000 performance specifications is shown in Figure 5. This data is also in numerical form in Table 2.

PARAMETERS	-75°F	70°F	150°F
Duration, Maximum (Sec)	19.45	14.65	12.0
Duration, Nominal (Sec)	18.3	13.7	11.2
Duration, Minimum (Sec)	16.9	12.8	10.55
Thrust, Maximum (Lb)	890	1160	1460
Thrust, Nominal (Lb)	790	1080	1360
Thrust, Minimum (Lb)	670	1010	1260

TABLE 2. Specification Data for Rocket Motors, 15-KS-1000.

STATIC FIRING.

All 24 test motors were fired without malfunction. Thrust and duration data were all within specification limits. Pressure and impulse data were satisfactory and all ignition delays were within the 0.5 second maximum allowable. A graphical comparison of test data with specification limits is shown in Figures 6 and 7. Data on motor manufacture and performance is outlined in Tables 3 and 4. A statistical evaluation of the data is covered in Table 5.

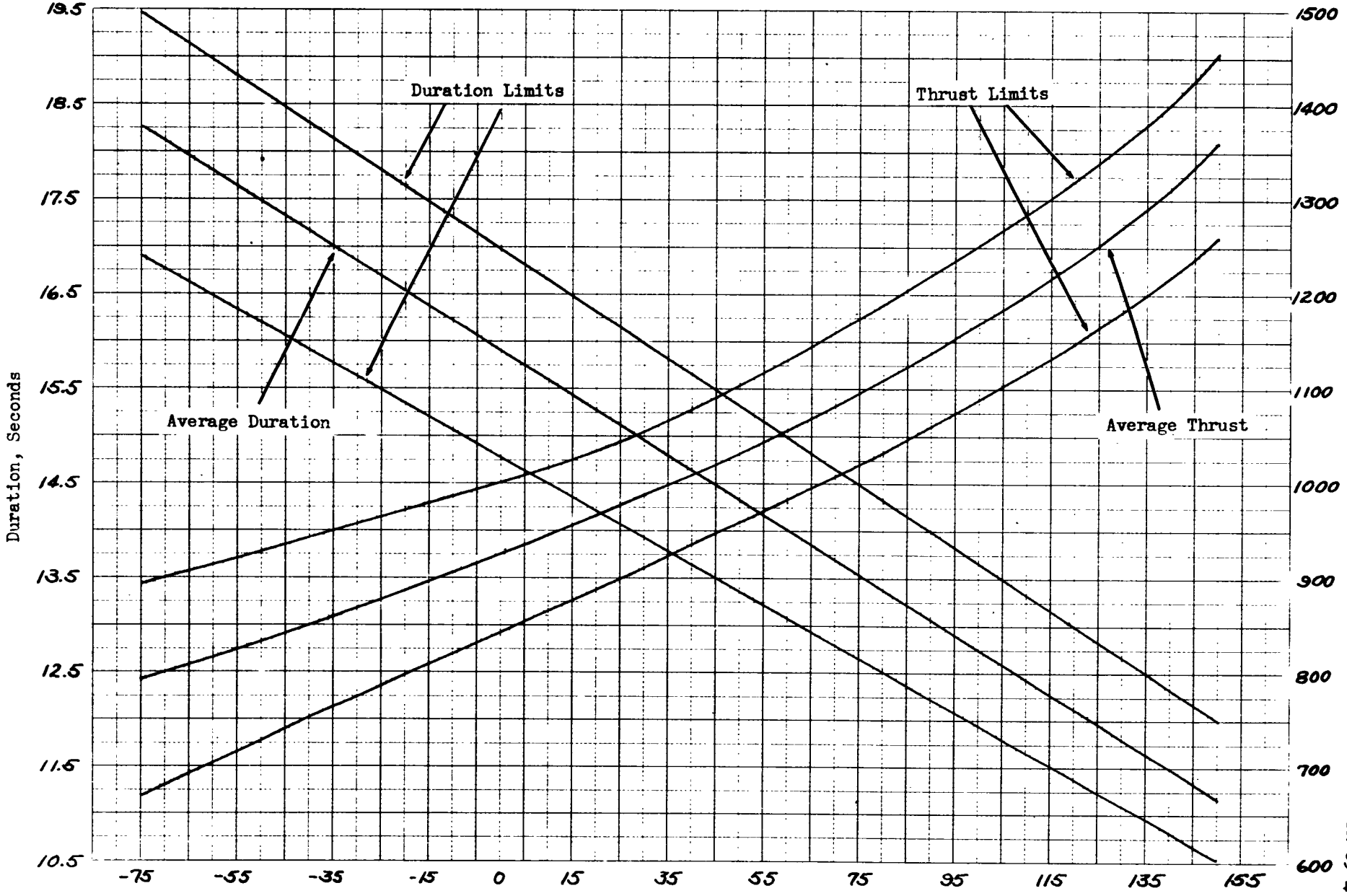


FIGURE 5. Performance Specification for the 15-KS-1000 Rocket Motor

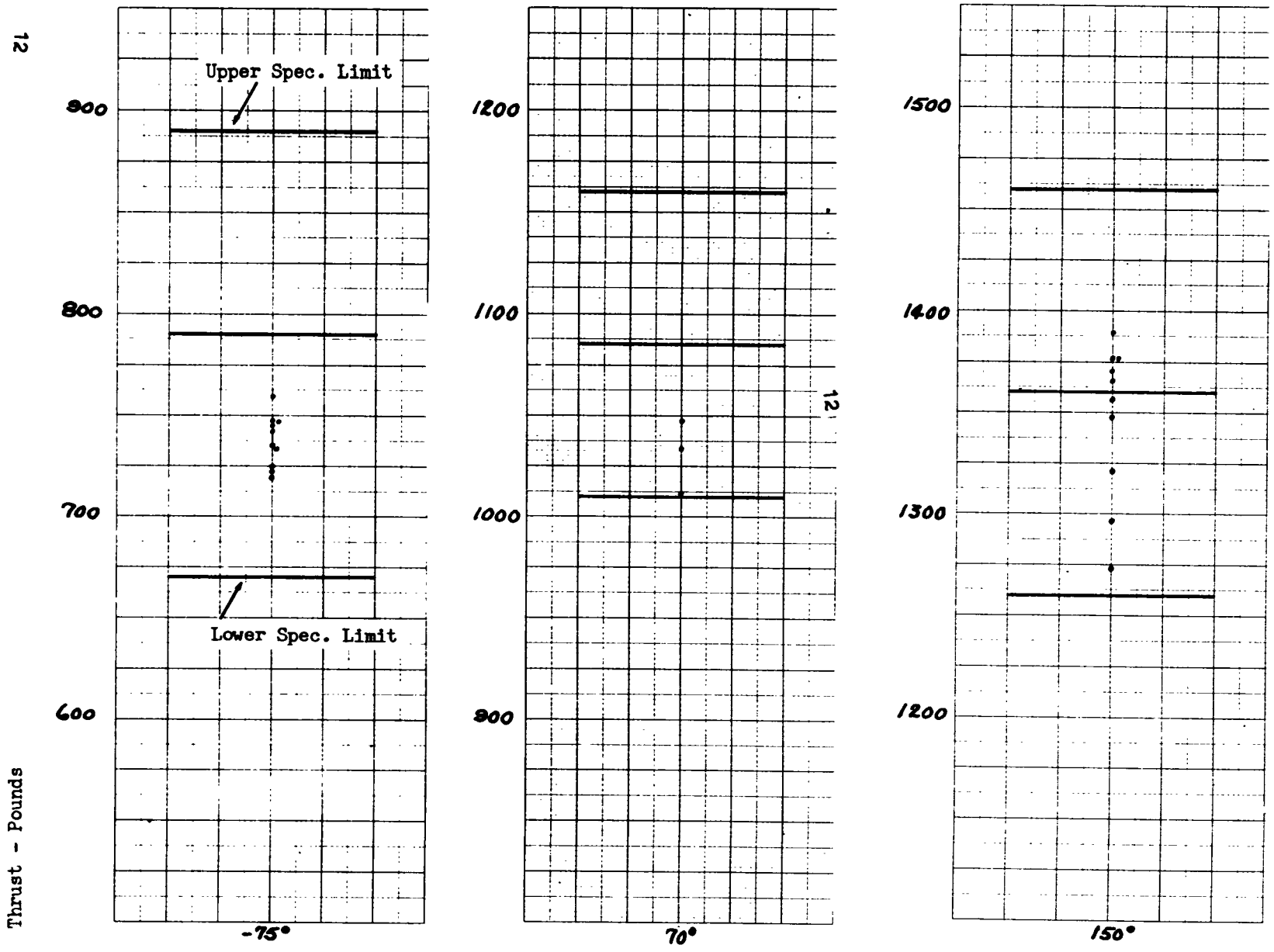


FIGURE 6. Thrust vs Temperature for 15-KS-1000 Rocket Motors, age 107 months

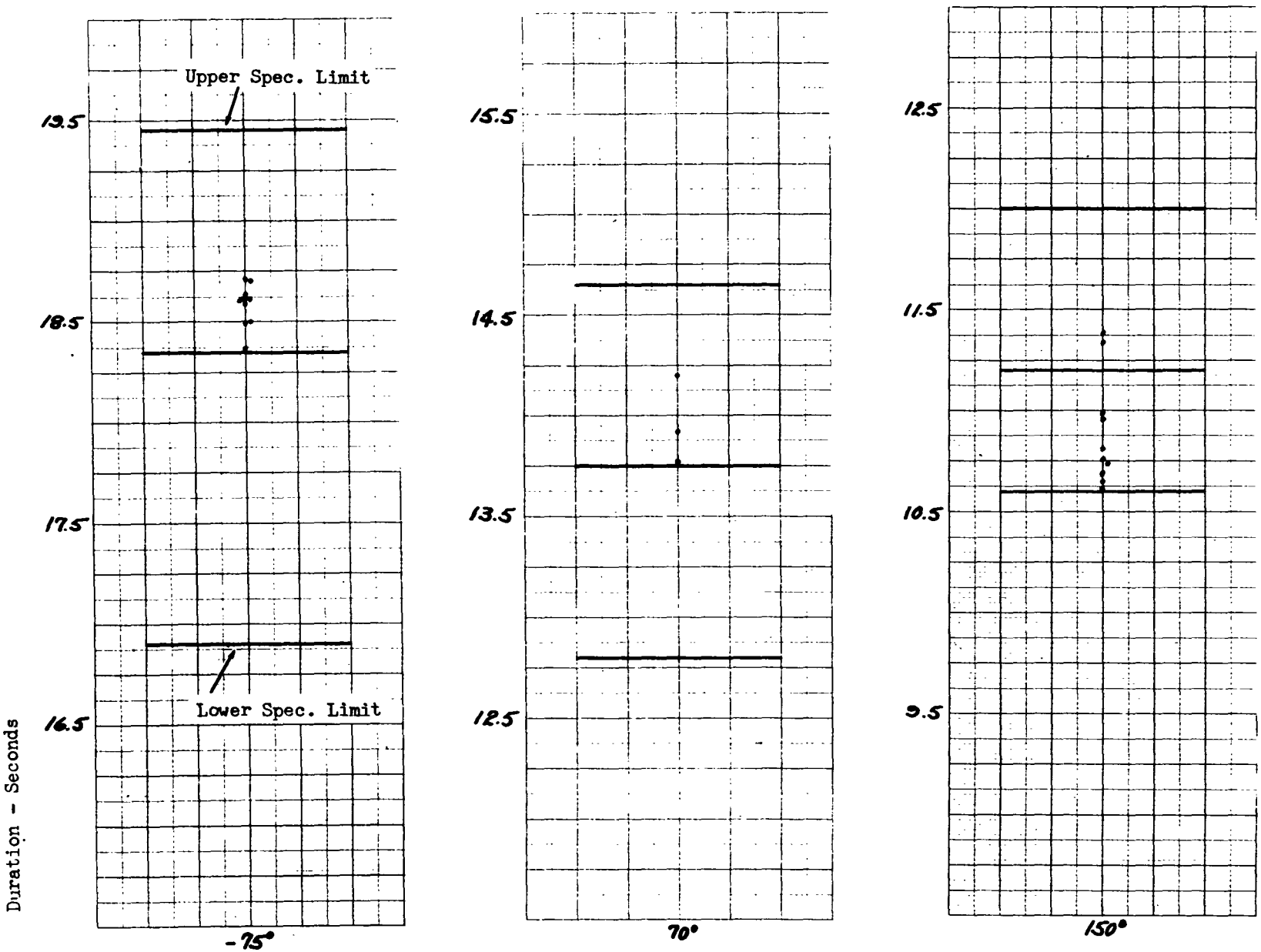


FIGURE 7. Duration vs Temperature for15-KS-1000 Rocket Motor, age 107 months

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MOTOR BATCH NO.	MOTOR NO.	TEMP (°F)	MOTOR MFG. DATE	IGNITER MFG. DATE	IGNITER RESIST. (Ω)	WEIGHT LOADED (LB)	WT. EMPTY (LB)	PROP. WT. (LB)
1-287	8	-75	5-53	8-54	0.25	137	64	73
1-287	10	-75	5-53	8-54	0.24	137	64	73
1-307	11	-75	5-53	8-54	0.56	137	64	73
1-287	13	-75	5-53	8-54	0.24	136	63	73
1-307	14	-75	5-53	8-54	0.34	137	63	74
1-287	15	-75	5-53	8-54	0.23	136	63	73
1-307	16	-75	5-53	8-54	0.37	137	63	74
1-287	17	-75	5-53	8-54	0.21	136	62	74
1-287	18	-75	5-53	8-54	0.57	136	63	73
1-287	19	-75	5-53	8-54	0.23	137	64	73
1-287	3	70	5-53	8-54	0.24	136	63	73
1-307	4	70	5-53	8-54	0.29	137	64	73
1-287	6	70	5-53	8-54	0.24	136	63	73
1-287	12	70	5-53	8-54	0.26	136	63	73
1-287	1	150	5-53	8-54	0.25	137	64	73
1-287	2	150	5-53	8-54	0.27	136	63	73
1-287	5	150	5-53	8-54	0.36	136	64	72
1-287	7	150	5-53	8-54	0.21	136	63	73
1-287	9	150	5-53	8-54	0.24	137	64	73
1-287	20	150	5-53	8-54	0.36	136	63	73
1-287	21	150	5-53	8-54	0.26	137	64	73
1-287	22	150	5-53	8-54	0.37	137	64	73
1-287	23	150	5-53	8-54	0.25	137	63	74
1-287	24	150	5-53	8-54	0.30	137	63	74

TABLE 3. Manufacture Data.

DEFINITION OF PARAMETERS

IGNITION DELAY (T_d)

Ignition delay is the time interval between fire switch and the point at which thrust reaches 250 pounds.

DURATION OF EFFECTIVE TIME (T_e)

The duration or effective time is the interval beginning when the thrust has risen to 250 pounds and ending when it has decreased to 250 pounds.

EFFECTIVE THRUST (F_e)

The effective thrust is the integral of the area under the thrust-time curve for the time period known as duration divided by the duration.

EFFECTIVE PRESSURE (P_e)

The effective pressure is the integral of the area under the pressure-time curve for the time period known as duration divided by the duration.

TOTAL IMPULSE (I_e)

The total impulse is the integral of the area under the thrust-time curve for the time period known as duration.

MOTOR NO.	TEMP (°F)	TIME		PRESSURE		THRUST		IMPLUSE		SPECIFICATION LIMITS					
		T_d (Sec)	T_e (Sec)	P_m (Psi)	P_e (Psi)	F_m (Lb)	F_e (Lb)	I_e (Lb.Sec)	I_{sp} (Lb.Sec/Lb)	THRUST (F_e)			TIME (T_e)		
										HIGH	NORM	LOW	HIGH	NORM	LOW
8	-75	0.31	18.59	497	413	891	746	13859	190	890	790	670	19.45	18.30	16.90
10	-75	0.43	18.71	497	416	891	736	13772	189	890	790	670	19.45	18.30	16.90
11	-75	0.29	18.63	497	415	875	723	13467	184	890	790	670	19.45	18.30	16.90
13	-75	0.24	18.37	497	426	875	759	13940	191	890	790	670	19.45	18.30	16.90
14	-75	0.41	18.70	497	414	891	725	13554	183	890	790	670	19.45	18.30	16.90
15	-75	0.34	18.49	497	413	875	747	13810	189	890	790	670	19.45	18.30	16.90
16	-75	0.28	18.50	507	416	907	734	13571	183	890	790	670	19.45	18.30	16.90
17	-75	0.43	18.62	497	413	891	747	13918	188	890	790	670	19.45	18.30	16.90
18	-75	0.32	18.61	478	413	860	743	13832	189	890	790	670	19.45	18.30	16.90
19	-75	0.29	18.62	507	416	891	722	13440	184	890	790	670	19.45	18.30	16.90
3	70	*	*	*	*	*	*	*	*	1160	1080	1010	14.65	13.70	12.80
4	70	0.34	13.77	*	*	1266	1048	14429	198	1160	1080	1010	14.65	13.70	12.80
6	70	0.28	14.20	*	*	1172	1012	14364	197	1160	1080	1010	14.65	13.70	12.80
12	70	0.32	13.92	675	562	1235	1033	14386	197	1160	1080	1010	14.65	13.70	12.80
1	150	0.28	10.97	891	727	1610	1322	14500	199	1460	1360	1260	12.00	11.20	10.55
2	150	0.14	10.62	910	755	1672	1377	14620	200	1460	1360	1260	12.00	11.20	10.55
5	150	0.21	10.81	900	739	1657	1366	14766	205	1460	1360	1260	12.00	11.20	10.55
7	150	0.25	10.98	863	719	1610	1348	14804	203	1460	1360	1260	12.00	11.20	10.55
9	150	0.34	10.64	910	752	1688	1389	14777	202	1460	1360	1260	12.00	11.20	10.55
20	150	0.14	11.39	882	700	1641	1297	14772	202	1460	1360	1260	12.00	11.20	10.55
21	150	0.24	11.34	835	706	1532	1273	14440	198	1460	1360	1260	12.00	11.20	10.55
22	150	0.19	10.68	910	751	1672	1362	14543	199	1460	1360	1260	12.00	11.20	10.55
23	150	0.19	10.76	900	737	1672	1377	14821	200	1460	1360	1260	12.00	11.20	10.55
24	150	0.26	10.74	891	750	1641	1371	14728	199	1460	1360	1260	12.00	11.20	10.55

TABLE 4. Performance Data.

* Data lost due to instrumentation failure.

KEY FOR TABLE 5

The statistical data in Table 5 was calculated using the following definitions and formulas:

$\bar{X}_n$ is the average value of the samples used.

$\bar{X}'$ is the estimated average range of the represented population.

σ_n is the standard deviation of the sample group

σ' is the estimated standard deviation of the represented population.

S.E. is the standard error of the mean which is used for determination of the range of average values to be expected for the represented population.

Xi Maximum and Minimum are the maximum and minimum individual values which are expected for represented population.

σ' is calculated from the following formula:

$$\sigma' = \sigma_n \sqrt{\frac{n}{n-1}}$$

S.E. is calculated from: $S.E. = \frac{\sigma'}{\sqrt{n}}$

To obtain $\bar{X}'$ values, the following was used:

$$\bar{X}' = \bar{X}_n \pm 2 \text{ S.E.}$$

Xi maximum and minimum values were calculated by:

$$\text{Xi Max \& Min} = 2 (\sigma' + \text{S.E.})$$

All statistical calculation was accomplished at the 95 per cent confidence level.

PARAMETER	TEMP (°F)	QUANTITY OF SAMPLES	$\bar{X}_n$	σ_n	S.E.	Xi	
						HIGH	LOW
Duration (sec)	-75	10	18.58	.098	.033	18.85	18.31
	70	3	13.96	.178	.126	14.65	13.27
	150	10	10.89	.263	.088	11.62	10.16
Pressure (psi)	-75	10	416	3.7	1.2	426	405
	150	10	734	18.9	6.3	786	681
Thrust (lbs)	-75	10	737	11.3	3.8	769	706
	70	3	1031	13.8	10.4	1088	974
	150	10	1348	36.5	12.2	1449	1247
Total Impulse (Lb.Sec)	-75	10	13716	180	60	14214	13218
	70	3	14393	27	19	14497	14289
	150	10	14677	132	44	15043	14311

TABLE 5. Statistical Evaluation of Data.

CONCLUSIONS

1. 15-KS-1000 Rocket Motors of age 10 years or less will perform within specification limits when subjected to temperatures now lower than -65°F or higher than 140°F.

2. The 15-KS-1000 units exhibit excellent resistance to damage caused by thermal shock or rough handling.

3. 15-KS-1000 Rocket Motors have a reliability of 99% at a 95% Confidence Level.

RECOMMENDATIONS

1. Recommend that the operational shelf life of the 15-KS-1000 Rocket Motors be extended to 10 years.

2. Recommend that tests be conducted annually to attempt further extension of the shelf life of this motor.

DISTRIBUTION LIST

3 Dep IG for Safety, Hq USAF (AFIGS-3), Norton AFB, Calif
1 Hq USAF (AFSSS-AE), Wash 25, DC
2 AFLC (MCSW and MCAS), Wright-Patterson AFB, Ohio
1 AUL, Maxwell AFB, Ala
20 ASTIA (TISIA-2), Arlington Hall Stn, Arlington 12, Va
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1 Safety Div (AMCAD-SA), US Army Mtel Comd, Wash 25, DC
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1 USAFE (MMD-H), APO 633, New York, NY
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1 AAC(ALDMS-1), APO 942, Seattle, Wash
1 NGB, Air Sys & Log Div (NG-AFSS), Wash 25, DC
1 CO (QE Lab), US Naval Weapons Stn, Seal Beach, Calif
1 CO (QE Lab), Naval Ammunition Depot, Concord, Calif
1 Comdr, US Naval Ord Test Stn (Code 556), China Lake, Calif
1 CO, US Naval Ammunition Depot (Code 35), Crane, Ind
1 Det 4, ASD (ASQWW), Eglin AFB, Fla
1 AFSC Engineering Office (ASNPESD), Hill AFB, Utah
1 Dep IG for Safety, Hq USAF (AFIMS-2), Norton AFB, Calif
1 6593d Test Gp (Devel)(DGSMS), Edwards, Calif
1 Allegany Ballistics Lab (Tech Lib), P O Box 210, Cumberland, Md
3 ~~Cml Prply~~ Info Agcy, John Hopkins Univ, Applied Physics Lab, (Attn: P.J. Martin, Asst Gp Suprv), 8621 Georgia Ave, Silver Spring, Md

Check Rec'd

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2705th Airmunitions Wing (OOAMA), Hill Air Force Base, Utah
SHELF LIFE TEST ON ROCKET MOTORS, 15-KS-1000, MK 6 MODS, by Robert M. Cavett, February 1963, 21p incl. figures and tables.
(OOY-TR-63-4) Unclassified Report

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UNCLASSIFIED

1. Rocket Motors

I. Robert M. Cavett

UNCLASSIFIED

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This investigation was one phase of a series established to determine the ultimate life of the 15-KS-1000 Rocket Motor. To accomplish this, motors were visually and radiographically inspected and fired using static facilities at Hill Air Force Base, Utah. In order to best evaluate serviceability, temperature conditioning was accomplished at both high and low extremes of 150°F and -75°F. The motors, as in the past, continued to function without incident. Some small drift of the data from normality toward the specifications limits was noted but was not significantly detrimental to effect serviceability. The previous established life of 9 years was confirmed and an extension to 10 years is recommended.

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